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TRAINING AND MENTORING

IUPS Physiology Education Workshop series in India: organizational mechanics, outcomes, and lessons

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Chandran DS, Muthukrishnan SP, Barman SM, Peltonen LM, Ghosh S, Sharma R, Bhattacharjee M, Rathore BB, Carroll RG, Sengupta J, Chan JY, Ghosh D. IUPS Physiology Education Workshop series in India: organizational mechanics, outcomes, and lessons. *Adv Physiol Educ* 44: 709–721, 2020; doi:10.1152/advan.00128.2020.—Active learning promotes the capacity of problem solving and decision making among learners. Teachers who apply instructional processes toward active participation of learners help their students develop higher order thinking skills. Due to the recent paradigm shift toward adopting competency-based curricula in the education of healthcare professionals in India, there is an emergent need for physiology instructors to be trained in active-learning methodologies and to acquire abilities to promote these curriculum changes. To address these issues, a series of International Union of Physiological Sciences (IUPS) workshops on physiology education techniques in four apex centers in India was organized in November 2018 and November 2019. The "hands-on" workshops presented the methodologies of case-based learning, problem-based learning, and flipped classroom; the participants were teachers of basic sciences and human and veterinary medicine. The workshop series facilitated capacity building and creation of a national network of physiology instructors interested in promoting active-learning techniques. The workshops were followed by a brainstorming meeting held to assess the outcomes. The aim of this report is to provide a model for implementing a coordinated series of workshops to support national curriculum change and to identify the organizational elements essential for conducting an effective Physiology Education workshop. The essential elements include a highly motivated core organizing team, constant dialogue between core organizing and local organizing committees, a sufficient time frame for planning and execution of the event, and opportunities to engage students at host institutions in workshop activities.

active learning; case-based learning; educational techniques; flipped classroom; networking; pedagogy; problem-based learning

INTRODUCTION

Active learning promotes thinking skills, logical reasoning, critical appraisal, and a capacity to build problem-solving and decision-making skills among learners (20). Teachers using instructional processes that encourage active participation of learners in the process of knowledge acquisition and the application of the knowledge develop higher order thinking skills in their students (2, 36). Abilities of critical thinking and problem solving are particularly integral to the process of acquiring effective understanding of physiological sciences (2). Student-centered active-learning methodologies improve the understanding of theoretical concepts, critical thinking, and problem-solving abilities of students of physiology (11, 19, 46).

Education in the healthcare profession across the globe is undergoing a major paradigm shift toward adopting competency-based curricula (22, 42). In consonance with this global trend, medical educationists in India and other countries in South Asia have emphasized the need to rebuild the curricular structure of medical education to foster future healthcare professionals who are competent to address the regional needs and challenges in the healthcare system from a societal perspective (24, 25, 30, 38, 41, 44). In a major move toward accomplishing this goal, the Medical Council of India (MCI), the apex regulatory authority of medical education in India, introduced a competency-based undergraduate curriculum for the Indian medical graduate (34) that became effective with the August 2019 academic session. Medical educationists and physiologists have anticipated the challenges in implementing a competency-based medical curriculum in India. These include the lack of adequate educational infrastructure and resources, a low faculty-to-student ratio that is detrimental to successful implementation of student-centered, active-learning approaches, and lack of motivation and cooperation among faculty members to embrace new educational roles and pedagogical strategies (6, 24, 39). The solutions proposed emphasize the need for rigorous training in newer methods of teaching/learning and assessment to facilitate optimal faculty development, consistent with the requirements of delivering a competency-based curriculum (6, 24, 39).

Adopting pedagogical strategies based on active learning has been proposed as a key approach to deliver competency-based medical education for healthcare professionals. Plans to transition from a content-based to a competency-based curriculum can follow a framework derived from Mento's 12-step change-

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management model (5). Self-regulated active learning promotes attainment and better retention of competencies involving technical and procedural skills among clinical residents (9, 16). Academic programs delivered using active-learning techniques improve critical care competencies of undergraduate pharmacy students (33) and core competencies of undergraduate nursing students (8, 43). An active-learning environment is considered as an essential prerequisite to nurture competent healthcare professionals capable of lifelong self-directed learning (8). Taking cognizance of these facts, there is an emergent need for physiology instructors in India to be trained in active-learning methodologies and to acquire requisite abilities to steer the recently introduced competency-based curricular shift. One challenge in implementing active-learning methodologies is to prepare instructors to rediscover their academic role as facilitators, which is integral to effective implementation of any learner-centric instructional approach.

To address this need, we organized a series of workshops on physiology education techniques at four centers in different regions of India in November 2018 and November 2019 as an International Union of Physiological Sciences (IUPS) initiative (14). As previously reported, the workshop series attempted to create awareness and a "hands-on" experience with three tools in active learning: case-based learning (CBL), problem-based learning (PBL), and flipped classroom (FCR) models among teachers in basic sciences and human and veterinary medicine in India (14). Additionally, attempts were made to create networks and working groups to facilitate the exchange of knowledge and best practices in teaching and to improve the teaching and learning of physiology to ensure appreciation of the complexities of physiological understanding among the undergraduate students, as recommended in the first IUPS global report on physiological sciences (28).

As originally envisioned in the 2017 IUPS report (28), the workshop series was planned to support individual instructor toward attainment and refinement of teaching approaches that promote active learning in the discipline of physiology. Around the same time, as mentioned above, the MCI projected a revision to the national undergraduate medical curriculum that emphasized competency-based education (34). The active-learning approaches planned for the workshop are particularly suited to support competency-based curricula (21, 27, 31). Consequently, workshops emphasized how the teaching approaches supported the new national curriculum and prepared participants with the skills needed to promote curriculum change in their home institutions.

This report describes how different organizational challenges were handled while developing and executing this series of workshops. Finally, we provide a comprehensive analysis of feedback received from the participants and observers on various aspects related to the planning, the conduct, and overall effectiveness of the workshop sessions. The goal of this report is to provide a model for developing and implementing a coordinated series of workshops to support national curriculum change.

Organizational Mechanics

In October 2017, one of us (D.G.) as the workshop convener initiated the idea to hold a series of Physiology Education workshops on learner-centric active methods of teaching physiology in India. As a part of this initiative, a process of dialogue was triggered involving several experts in IUPS and India based on the recommendations given in the first global status report on physiological sciences presented at the XXXVIII IUPS Congress in early August 2017 (28). The following sections provide a brief outline of the cardinal steps that were followed in the process.

Formation of committees. In a sequential manner, three committees were formed to address different aspects of the planning and execution of the workshop-related activities. First, attempts were made to constitute a Core Organizing Committee (COC) and an International Advisory Committee (IAC), both of which were finalized in March–April 2018. The COC was formed in All India Institute of Medical Sciences (AIIMS), New Delhi, which is a premier medical institute in India, and consisted of a group of invited faculty members who were motivated to work for the cause of improving physiology education in India. Committee members hailed from medical institutions within New Delhi and from two neighboring states so that frequent meetings and interactions of the committee could happen at the conference secretariat located in New Delhi without any travel related hassles. Members of the COC represented a cross section of the institutional diversity prevailing in India with reference to nonequitable access to infrastructure and resources and career priorities in education and research. This enabled the COC as a team to ascertain effectively the organizational challenges associated with the conduct of a multicentric workshop series in India. The COC also explored the issue of procuring funds for the workshop series.

The IAC consisted of experts within and outside of India and included the President of the IUPS, the Chair of the IUPS Education Committee, the Chair and Vice Chair of the Board of General Assembly (BGA) of the IUPS, a member of the BGA, a member of the IUPS Education Committee, and a faculty member of the Centre for Education, International Medical University, Malaysia. The IAC members contributed immensely to architecting the overall design and course structure of the workshop series.

After identification of centers in different parts of the country, the local organizing committees (LOCs) for respective venues were formed. The LOCs were entrusted with the charge of organizing various aspects of the workshop activities, local hospitality of workshop participants and resource faculty both from within and outside India, and to obtain the necessary administrative clearances to hold the workshop and associated activities. Accordingly, the LOCs provided a budgetary request for each center in an itemized manner to the COC. The details of these workshop meetings are available in a report (14). Figure 1 provides the schema of the timeline of activities and processes involved in the planning and implementation of the proposed series of workshop.

Organizational process employed for workshop 1–3. Discussions involving the COC and the IAC zeroed in on three active-learning modes: CBL, PBL, and FCR. Inquiry-based learning methods such as PBL and CBL offer an opportunity to debate and argue confrontational issues in scenarios that are complicated by an increasing load of new evidences; PBL and CBL also motivate teachers to use their knowledge base and critical reasoning skills. Such debating improves the analytic decision-making, communication, and critical-thinking skills of the learners, making such active-learning tools useful for teachers-facilitators (23, 37). FCR is a special hybrid teaching model combined with team-based and evidence-based learning tools

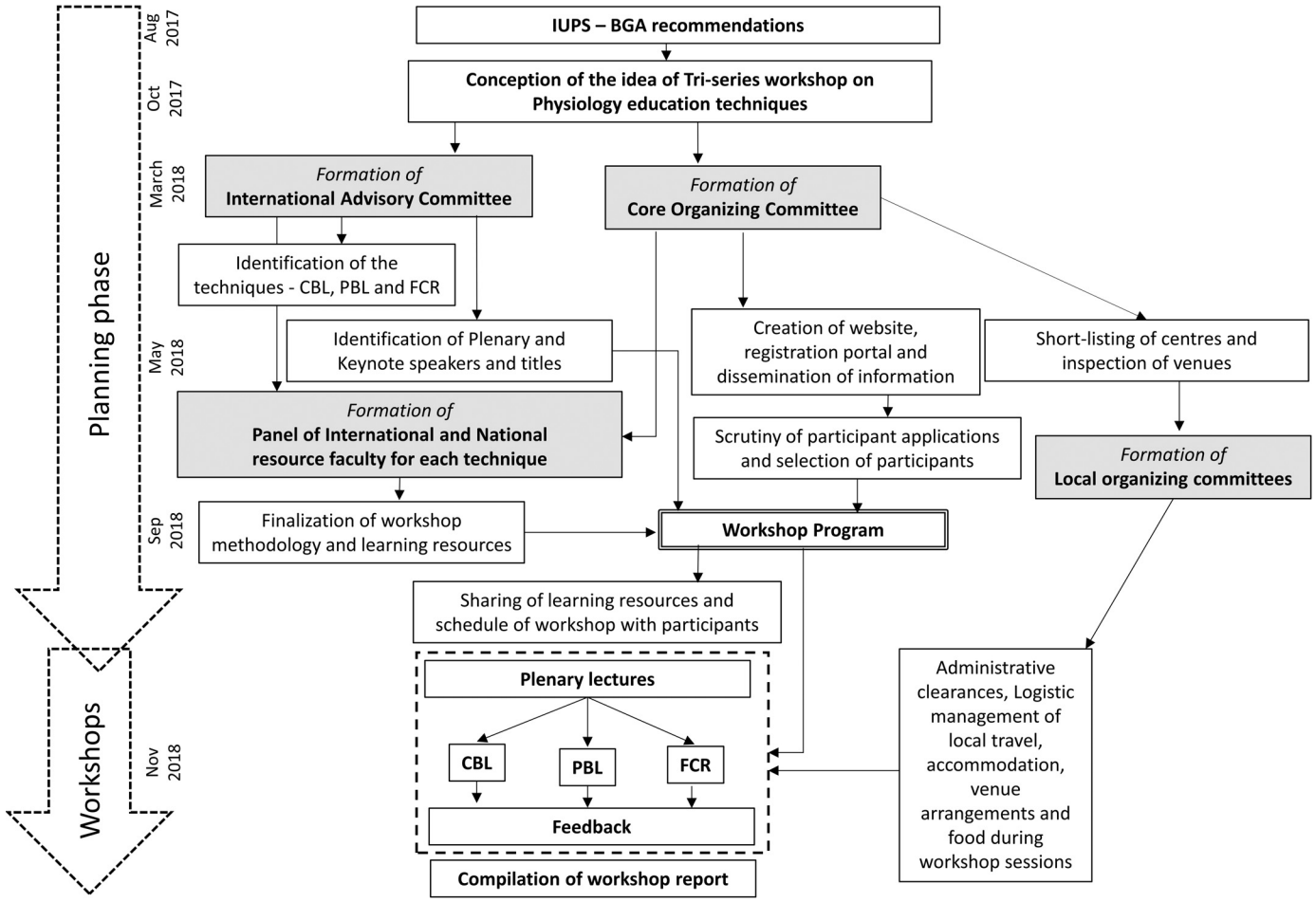


Fig. 1. Schematic representation of the activities and processes involved in the planning and implementation of the workshops held in November 2018 and November 2019. BGA, Board of General Assembly; CBL, case-based learning; FCR, flipped classroom; IUPS, International Union of Physiological Sciences; PBL, problem-based learning.

that is gaining acceptability (17). Indeed, there is evidence that the use of such teaching tools in combination provides success in their implementation for both medical students and teachers (3, 26). The methodological details of these three tools that were undertaken in the workshops at each center are found in the meeting report (14). Furthermore, a panel of willing resource faculty of international and national experts served as facilitators for each technique; they committed to contribute actively to the preparation of materials and to function as resource faculty at two or more centers (14). Subsequently, the COC identified the main anticipated challenges and possible ways of handling those challenges, as summarized in Table 1.

The COC chose to conduct the three workshops in different regions of India: one that catered to participants from the west of India, one from the east, and one from the southern region of India. Thus the tri-series Physiology Education workshops were held at apex centers of learning in three geographical regions of India: AIIMS Jodhpur, Rajasthan (*workshop 1*), North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS) Shillong, Meghalaya (*workshop 2*), and Government Medical College (GMC) Kozhikode, Kerala (*workshop 3*). The choice for these three venues rested on the diverse population of teachers and students based on their geo-ethnic and linguistic backgrounds. It also allowed the selected participants to join the respective workshop without having to travel long distances from their own institutions (see Fig. 2 for locations).

Following finalization of the workshop venues, between May and August 2018, the COC undertook the following activities deemed critical to ensure coordination, effective communication, and organizational synchrony between various stake holders at all stages of the conduct of the workshop series:

- Creating a website (40), which was announced in the portals of IUPS, Indian Council of Medical Research (ICMR), and physiological associations in India.
- Arranging site visits to the centers by an ad hoc committee consisting of the Chair and at least two members of the COC and a member of the IAC to inspect the host institution's logistics and feasibility to conduct the workshop as per the plan.
- Forming the LOC at each center and identifying dates in November 2018 based on the availability of the facilitators. After intense deliberations, the dates for three workshops were finalized as follows:
  - *Workshop 1* (AIIMS Jodhpur): November 3–5, 2018
  - *Workshop 2* (NEIGRIHMS Shillong): November 10–12, 2018
  - *Workshop 3* (GMC Kozhikode): November 15–18, 2018

Table 1. *Organizational challenges identified and the solutions administered*

Challenges	Solutions
Demographic challenges	
India being home to population of 135 crore (1.35 billion); bearing geographic, linguistic, and ethnic diversities; and residing in more than 3 million km^2 landmass area.	Decision to conduct a series of at least three workshops to be held sequentially in a time frame of 3 wk, around the same time in 2018 at three venues in India: west, east and south to ensure: *1*) Participation of large number of applicants. *2*) Participation of international resource faculty. *3*) Creation of networks among participants. *4*) Maintenance of relative uniformity in the training process.
Challenges related to educational practices in India	
The available proximate principles of active learning are generally not practiced in Indian schools. Students and teachers in professional, life science, and paramedical courses are usually unaware of the related culture and practice. Active-learning methods are not widely used in health profession, veterinary, and life science education across India.	Proactive measures adopted to prime the participants on active-learning techniques in the following ways: *1*) Learning material on each tool, which included published scientific literature, were created and curated by the Workshop Core Organizing Committee (COC) with collaboration of International Advisory Committee (IAC). *2*) All text material was published by the Organizing Secretariat for quality assurance and distributed to all participants 2 wk in advance for their preparatory study.
Challenges of scaling up the number of workshops	
Organizational challenges of conducting a multicentric workshop series with assurance of uniformity in quality at different geographical locations.	*1*) Site visits by the COC ahead of each workshop to satisfy quality assurance in meeting conductance by the Local Organizing Committee (LOC) in all manner of operation. *2*) Formation of a team of resource faculty members who could take part in at least two workshops. *3*) All hardcopy and softcopy resource material created, published, and dispatched to LOCs and individual participants by the Organizing Secretariat.
Challenges of meeting financial requirements.	*1*) Assuring critical budgetary requirements to the LOCs on the basis of their respective projected costing. *2*) Seeking financial support from Indian Council of Medical Research (ICMR). *3*) Managing ancillary support from different agencies to support noncore and additional local activities. *4*) Financial handling and common material expenditure by the Organizing Secretariat. *5*) Ensuring optimal use and allocation of resources.

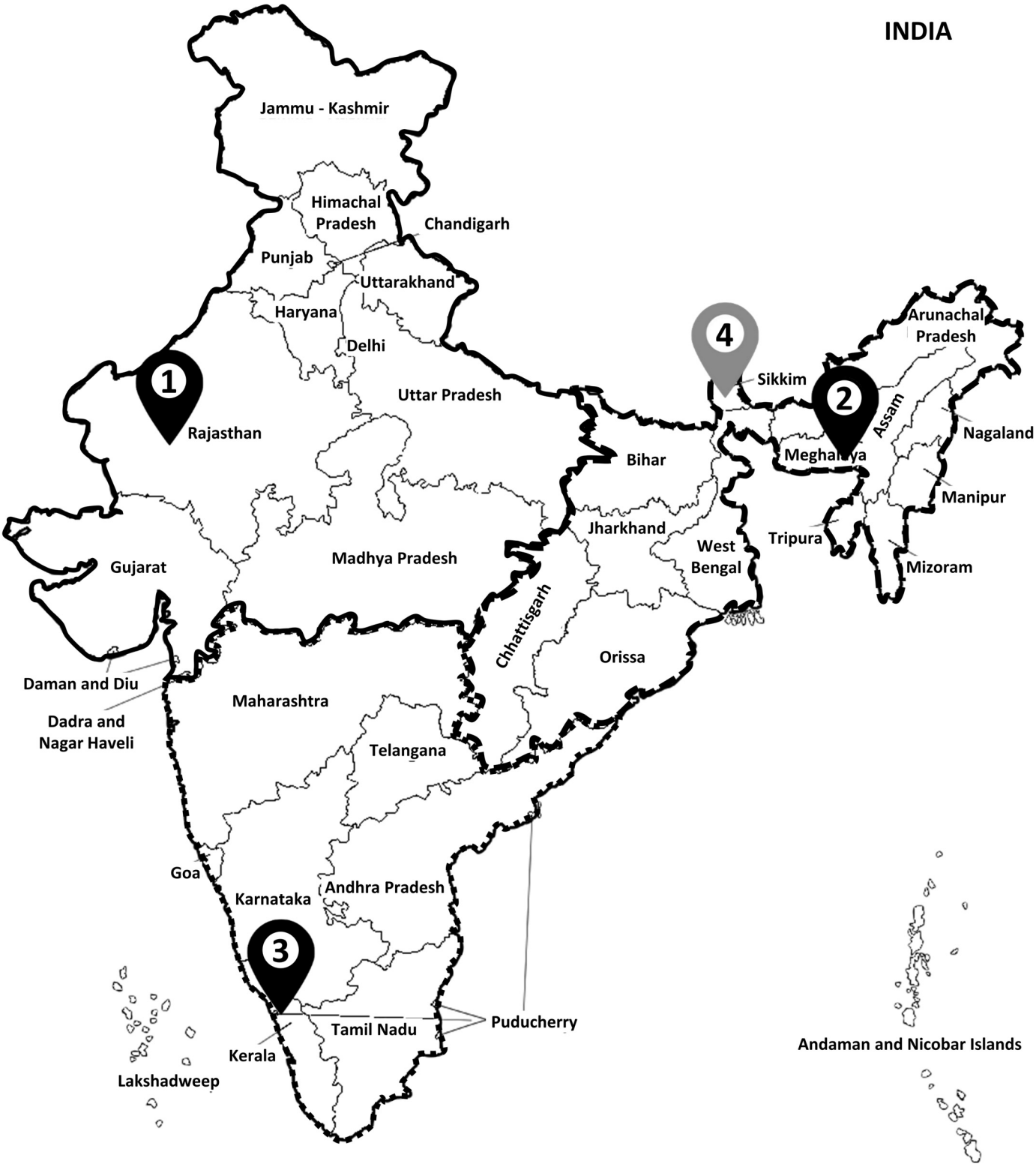
- Holding discussions with the LOCs regarding various aspects of their activities, including local hospitality of workshop participants and resource faculty from both within and outside India.
- Finalizing budgetary projections for each center in an itemized manner based on inputs received from respective LOCs.
- Managing an online registration portal for eligible candidates to submit their applications.
- Selecting the participants after close scrutinization of the applications by the COC based on predefined criteria of teaching experience in physiology/physiological sciences and stated interest in educational teaching methods.

The list of selected participants was shared with the respective LOCs for onward communication. The COC Chair and a panel of resource faculty members developed the workshop methodology, identified the learning resources, and created the text material that was shared online with all participants 2 wk before the start of each workshop.

The details of the workshop methodology have been reported (14). In brief, the 3-day workshop consisted of daily plenary lectures, followed by small-group, hands-on training on CBL, PBL, and FCR conducted as three parallel single-day sessions. Participants were divided into three groups and were rotated daily among the three active-learning sessions so that each participant was exposed to all of the techniques over the 3-day workshop at each center. Hands-on training sessions commenced with interactive audiovisual presentations or role plays to convey the premise and relevance of each technique and were followed up with live demonstrations and hands-on exposure using standard methodology to impart the essential background knowledge and know-how required to administer each technique. Each workshop session ended with interactive open discussions by participants with the resource team to share their unique challenges and to identify solutions specific to their academic settings.

At least two senior teachers of physiology or medical education from different parts of India were invited as "observers" for each center; they academically interacted with participants and resource faculty in all sessions and provided their objective and narrative feedback of the sessions to the COC. Observer feedback was collected as an essential part of the multisource feedback (MSF). MSF often includes assessments from others in a position to give a relevant judgement of one or more aspects of the activity to support quality improvement and decision making (32, 45). In this case, judgement was made of the general course of the various workshop sessions, academic engagement of participants, and the performance of the resource faculty. The constructive critiques of the workshop provided by the observers indeed offered a robust set of data to analyze the workshop outcomes. Inclusion of more than one observer brought variety

to the opinions, inputs, and perspectives in the feedback obtained and helped logistically in attaining optimal observer-participant interactions in all workshop sessions. It was anticipated that the "observers" would play the role of catalysts to promote learning-centric active education in physiology in their plane of hierarchy. Additionally, members of LOC secretariats of each of the three workshops were encouraged to attend all workshops. It was assumed that the subsequent LOCs would take note of organizational and managerial aspects important for their own activities at their centers, and that the interaction would help form networks among LOCs. Such engagement might ensure overall success of the workshops with uniformity



of performance. All participants and observers provided to the COC their structured and nonstructured feedback at the end of each active-learning session (CBL, PBL, and FCR) and at the end of the workshop for analysis of outcomes and future planning.

Brainstorming and workshop 4. In January 2019, 7 wk after *workshops 1–3*, a brainstorming meeting was conducted at AIIMS, New Delhi; it was coordinated by the Chair of the BGA and Chairperson and Convener of the tri-series workshop (29). It aimed to:

- Analyze outcomes and opportunities for improvement of *workshops 1–3*.
- Analyze the reports from the participants of *workshops 1–3* who conducted CBL, PBL, and FCR sessions within and outside their own institutions after attending the tri-series workshop.
- Hold an open discussion of various aspects of competency-based medical education that was to begin in August 2019 in medical colleges under MCI across India (34).

The meeting was attended by members of the COC, secretaries of the LOCs of the workshops, and representative participants from each center. A significant outcome of the brainstorming meeting was the acceptance of a proposal forwarded by a participant in *workshop 2* to hold a "Hands-on workshop on Medical Teaching Methodologies" in Sikkim Manipal Institute of Medical Sciences (SMIMS), Sikkim Manipal University (SMU), under the direct guidance of the COC. This workshop was subsequently held on November 5–7, 2019 and followed the working template of the previous tri-series workshop. The coverage in this event was extended to include interested participants from all preclinical, paramedical, paraclinical, and clinical disciplines. It was designated as *workshop 4* (see Fig. 2 for the location).

Feedback inputs and their analyses. Structured feedback was collected from participants and invited observers using feedback survey forms circulated at each workshop venue. The feedback questionnaires were developed and validated jointly by members of COC and the panel of international and national resource faculty. Briefly, two feedback forms were used:

1) A General Feedback Questionnaire collected feedback on *a*) overall conduct of workshops to address aspects pertaining to the planning and conduct of the workshop, and *b*) impact of the workshop on the knowledge, attitude, and skills of the participants pertaining to physiology education techniques.

2) A Session Assessment Questionnaire collected feedback on effectiveness of the conduct of each technique using 14 items rated on a 5-point Likert scale.

These questionnaires are available as supplemental material in a generalist public access repository (Open Science Framework) (Supplemental Material S1 and S2; see https://mfr.osf.io/render?url=https%3A%2F%2Fosf.io%2Ftsw85%2Fdownload, and https://mfr.osf.io/render?url=https%3A%2F%2Fosf.io%2Fkujfc%2Fdownload).

The Session Assessment Questionnaires were submitted at the end of each day's sessions, and the General Feedback was received on the concluding day of the workshop. Anonymity of the respondents of the feedback forms was ensured to encourage genuine feedback. The responses obtained from participants and observers of the 2018 workshop series and the 2019 workshop (*workshops 1–4*) were processed for both critical and narrative analysis and systematic and quantitative analysis with prior consent obtained from each participant. The collected feedback received from participants from each center was analyzed, and the descriptive statistics of the scores and the proportions of binary responses were centerwise collated for *workshops 1–4*. Feedback responses received from 61 participants who had attended the tri-series workshops and 44 participants who had attended *workshop 4* were subjected to statistical analysis pertaining to comparison of scores and proportions by applying appropriate statistical tests using SPSS version 20.0 and GraphPad Prism 8.4.3.

Outcomes Analysis

The following section summarizes the major observations on various outcomes collected from the itemized, structured, and narrative feedbacks received from the participants and observers in *workshops 1–4*.

Assessment of the workshops. Generally, the participants and observers appreciated the workshops. Highly positive responses were noted in the General Feedback and the Session Assessment Questionnaires from the participants, with median Likert scale scores for various points of assessment varying between 4 or 5 (see Tables 2 and 3 for details). The Likert scores given by observers for various items of assessments concurred with that of participants and were within the range of 25th to 75th percentiles of participant scores. As seen in Table 3, responses for the questions in the Session Assessment Questionnaire did not differ statistically between the tri-series workshop (*workshops 1–3*) and *workshop 4*, except in response to two questions related to the PBL session, with an improvement noted in *workshop 4*, i.e., *question 9* (effective time utilization; Mann–Whitney U score = 1,076; $P = 0.003$) and *question 13* (achievement of objectives; Mann–Whitney U score = 1,209; $P = 0.033$). This improvement may be attributed to the "learning effect" of experiences gained and real-time feedbacks received during the conduct of *workshops 1–3* on the team of resource faculty. However, it is not evident whether the observed differences occurred due to real objective reasons, or some subjective component playing a role, or both. PBL as a tool is known to reflect significant subjective issues, like learners' perceptions of

Fig. 2. Geographical locations of the centers for workshop series on Physiology Education Techniques in November 2018 and November 2019. *1*: All India Institute of Medical Sciences (AIIMS), Jodhpur, Rajasthan, November 3–5, 2018; *2*: North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong, Meghalaya, November 10–12, 2018; and *3*: Government Medical College Kozhikode, Kerala, November 15–18, 2018. *4*: Hands-on Workshop on Medical Teaching Methodologies at Sikkim Manipal Institute of Medical Sciences (SMIMS), Sikkim Manipal University (SMU), Gangtok, Sikkim, November 5–7, 2019. Three territories marked by respective outlines demarcate the geographical limits and the states included under the northern (solid line; states included Jammu and Kashmir, Himachal Pradesh, Punjab, Delhi and NCR, Uttarakhand, Rajasthan, Haryana, Uttar Pradesh, Madhya Pradesh, Gujarat), eastern (dashed line; states included Arunachal Pradesh, Andaman and Nicobar islands, Assam, Nagaland, Meghalaya, Manipur, Mizoram, Sikkim, Tripura, West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha), and southern (dotted line; states included Maharashtra, Telangana, Karnataka, Andhra Pradesh, Tamil Nadu, Puducherry, Kerala) chapters catered, respectively, by AIIMS Jodhpur, NEIGRIHMS Shillong, and Government Medical College Kozhikode. (Source of the atlas used: https://commons.wikimedia.org/wiki/File:India-map-en.png#/media/File:India-map-en.png).

Table 2. *Quantitative data based on participants' General Feedback survey*

No.	Question	Median (25th–75th Percentile) Score on the Likert Scale			
		WS1	WS2	WS3	WS4
Section A: Workshop planning					
1.	Adequate information about the workshop was provided well in advance.	5 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)
2.	The aim of the workshop appeared significant to me.	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)
3.	The duration of the workshop was appropriate.	4 (3.5–4)	4 (4–5)	4 (4–5)	4 (4–5)
4.	Adequate materials were provided during the workshop.	4 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)
Section B: Format of the workshop					
5.	The general atmosphere of the workshop was conducive.	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)
6.	Adequate time required for critical and interactive learning was provided in the workshop.	4 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)#
7.	The pace of the workshop was appropriate.	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)
8.	The topics presented were relevant to the aim of the workshop	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)

		Participants Who Agreed, *n*			
		WS1	WS2	WS3	WS4
Section C: Gain in knowledge, skills, and attitude (yes/no questions)					
9.	You were familiar with the content presented in this workshop.	8/21	10/16	13/24	16/44
10.	You gained new skills that may help you in your future teaching activities.	21/21	16/16	24/24	44/44
11.	You think PBL, CBL, and FCR provide good options to promote active learning.	21/21	16/16	24/24	44/44
12.	You will be able to apply in your parent institute some of the tools presented in this workshop.	21/21	16/16	22/24	NA*

		Participants Who Responded, *n*			
		WS1	WS2	WS3	WS4
Section D: Comments and suggestions					
13.	Please give general comments on the planning, conduct, and academic and organizational aspects of the workshop.	20/21	13/16	24/24	25/44

Values are median (with 25th to 75th percentile in parentheses) for sections A and B; *n*, no. of participants who agreed out of the total number of responses received (section C); or *n* participants who responded out of the total number of responses received (section D). Results are based on feedback received from delegates from the tri-series workshops (WS) 1–3 and from WS4. Likert scale: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. CBL, case-based learning; FCR, flipped classroom; PBL, problem-based learning. **Question 12* in WS4 was replaced by another question on the same theme, i.e., feasibility of the techniques demonstrated in the workshop in their parent institute. Kindly refer to Fig. 3 for the results of the aforementioned question in WS4. #Significantly higher in WS4 compared with the pooled data of WS1–WS3.

the learning environment in various institutional contexts and the impact of the disciplines from which they hail (18).

Response scores obtained for each item in the Session Assessment Questionnaire compared across the three techniques (PBL, CBL, and FCR) did not reveal any statistically significant differences. This could be attributed to the concerted and coordinated efforts of the COC and the teams of resource faculty in ensuring uniform quality in the content and delivery of the workshop program across the three active-learning strategies.

Table 4 shows snapshots of a few relevant nonstructured, open comments received from the participants of *workshops 1–4*. Generally, participants commented that the academic activities in the workshops were well organized and coordinated, and that resource faculty members fulfilled their expectations and encouraged the development of cohort groups with cooperation in the application of new concepts of active learning and team learning. Several participants noted that they would recommend their colleagues to attend such workshops. Many participants expressed their plan to attend similar workshops in the future. A participant summed it up well: "This workshop will surely create dynamic teachers and will help to make learning a joyful experience for students."

Table 5 displays snapshots of some of the relevant open comments and recommendations received from the observers. In general, observers appreciated the need to conduct such educational workshops in India, especially in the wake of newly implemented competency-based undergraduate medical curriculum by MCI, which advocates use of student-centered, active-learning approaches as the key to attain the competencies expected of a medical graduate.

Participants' inputs regarding the educational tools presented in the workshops. One in every two participants of *workshops 1–3* was familiar with at least some of the contents related to the techniques presented in the workshops, whereas only one in every three of the participants of *workshop 4* had prior familiarity with these techniques. However, this observed difference bears little significance, as the participants of *workshops 1–3* were exclusively teachers of physiology, whereas the participants of *workshop 4* were both teachers and residents who hailed from several disciplines and departments of a medical school. Despite several variabilities that existed in the final execution of the workshops, some of which are addressed in this report, participants of all four workshops agreed to the statement that CBL, PBL, and FCR are educational techniques that promote active learning (see *question 11* in Table 2 and comments in Table 4).

In *workshop 4*, additional feedback was sought from participants to rank the three tools (CBL, PBL, and FCR) based on their feasibility to be implemented as active-learning techniques. Eighteen out of 41 participants who responded to this question ranked FCR as the most feasible technique, followed by PBL (15 out of 41) and CBL (8 out of 41). However, these differences were not statistically significant. Further analysis was conducted to relate the preferences for each technique and

Table 3. *Quantitative data on participants' feedback for Session Assessment Questionnaire*

		Median (25^{th}–75^{th} Percentile) Score on the Assessment Scale											
		CBL				FCR				PBL			
No.	Question	WS1	WS2	WS3	WS4	WS1	WS2	WS3	WS4	WS1	WS2	WS3	WS4
1.	Quality of preparatory material	4 (4–5)	4 (3–5)	4 (4–5)	4 (3–4)	4 (4–5)	4 (3–4)	4 (3–5)	4 (4–4)	4 (3–4)	4 (3–4)	4 (3–4)	4 (4–5)
2.	Explanation of content	4 (4–5)	4 (3–5)	4 (4–5)	4 (4–5)	5 (4–5)	4 (3.75–4)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)
3.	Clarity and style of presentation	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)
4.	Use of audiovisual aids	4.5 (4–5)	4 (3.75–5)	4 (4–5)	4 (4–5)	5 (4–5)	4.5 (3–5)	4 (3–5)	4 (4–5)	4 (3–4)	4 (4–5)	4.5 (4–5)	5 (4–5)
5.	Utility of materials provided	4 (4–5)	4 (3–5)	5 (4–5)	4 (4–5)	4 (4–5)	4 (3–5)	4 (3.75–5)	4 (4–5)	4 (3–5)	4 (4–5)	4 (3.25–5)	4 (4–5)
6.	Demonstration of technique	5 (3.25–5)	4.5 (4–5)	5 (4–5)	4 (4–5)	4.5 (4–5)	4 (4–5)	4.5 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)
7.	Quality of interactive sessions	5 (4–5)	4.5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)
8.	Rank the facilitators	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	4.5 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)	4.5 (4–5)	5 (5–5)	5 (5–5)
9.	Effective time utilization	4 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4.5 (4–5)	4 (4–5)	4 (3–5)	4 (3–5)	4 (4–5)	5 (4–5)*
10.	Hands-on experience	4.5 (3–5)	5 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	4.5 (4–5)	5 (4–5)
11.	Sufficient time allotted	5 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4.5 (3–5)	4 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)
12.	Comfort and adequacy of venue	4.5 (4–5)	4 (3.75–5)	4 (4–5)	5 (4–5)	5 (4–5)	4 (3.75–5)	4 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)
13.	Achievement of objectives	4 (4–5)	5 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	4 (3.75–5)	4 (4–5)	4 (4–5)	4 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)*
14.	Overall experience	4 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	4 (4–5)	5 (4–5)	5 (4–5)	5 (4–5)

Values are median (with 25^{th} to 75^{th} percentile in parentheses). Assessment scale: 1, below average; 2, average; 3, good; 4, very good; 5, excellent. WS1–WS4, *workshops 1–4*. CBL, case-based learning; FCR, flipped classroom; PBL, problem-based learning. *Significantly higher in WS4 compared with pooled data of WS1–WS3.

whether the participant belonged to preclinical/paramedical (pooled together) or paraclinical/clinical disciplines. Figure 3 depicts the descriptive data of the same. FCR was the tool of choice by participants from the preclinical sciences, paramedical, and allied health sciences. This may reflect their appreciation for a student-centric learning process more geared toward in-depth understanding of the subject. This observation finds support on the use of FCR in medical schools (3, 10, 17, 26). Although the overall responses ranked FCR as the most feasible technique, a closer analysis revealed that, for paraclinical and clinical participants of *workshop 4*, the choice was more toward problem-solving through PBL and CBL. It is likely that the participants from paraclinical and clinical sciences reflected their choice for PBL and CBL due to use of associated real-case scenarios in the teaching-learning process (35). Although no firm

Table 4. *Snapshots of comments by the participants of workshops 1–4*

About the workshop

- "Workshop provided self-confidence in teaching skills and also tools to communicate and collaborate."
- "The workshop was an eye-opener toward changing the style of teaching to make students show more interest in the subject."
- "This workshop will surely create dynamic teachers and will help to make learning a joyful experience for students."
- "Changed the perception of teaching-learning. Exceptional and excellent."
- "Loved the congenial nature and approachability of resource faculty."

About the active-learning tools

- "Active-learning tools may help students to avoid confusions, although application of these tools may be a challenge."
- "Good motivation for active learning for students and distinguishing the slow learners."
- "PBL, CBL and FCR can be introduced into the curriculum with a part of the credit or marks included in the internal assessment."
- "While teaching PBL and CBL, non-medical problems may be used so that one can concentrate on the technique rather than the subject content."

Recommendations

- "Workshop to be made mandatory for faculty members as a part of their training during induction into service, channels created to remain in communication with the resource faculty."
- "Workshop should go beyond sensitization, the tools to be imposed into the regular curriculum by the Medical Council of India (MCI) and the Heads of Institutions as the need of the hour in the current education system. Yes, we respect the old traditional way of teaching, but at the same time with the current situation there is a need of transformation. Hence there will be uniform standard of learning for the students and (make it) legalized by the Government of India and the MCI."
- "Workshops may be designed in the future to promote how to design a curriculum to cater to courses in physiology and the assessment tools."
- "Veterinarians may join such workshops with more time for "hands on" activities for better practical experience. Wider publicity be given for such workshops when organized in the future with information shared with the Indian Council of Agricultural Research."
- "Such a workshop was long sought after, physiologists should encompass these techniques to survive and being overshadowed by other competing subjects."
- "The IUPS to focus not only on medical teaching but also on research and how to approach its funding; workshops should be conducted to bridge these gaps in India."

CBL, case-based learning; FCR, flipped classroom; IUPS, International Union of Physiological Sciences; PBL, problem-based learning.

Table 5. *Snapshots of comments by the observers of workshops 1–3*

About the workshop
• "Academic and organizational aspects of the workshop are excellent. Resource faculty were very co-operative, patient and helpful in guiding through all the steps of group activities."
• "The academic outcome was reached as the participants expressed their desire to implement at their own set up."
• "This kind of workshops are the need of the hour, especially to sensitize/expose the teachers/faculty members to newer pedagogic strategies, specifically in the light of new competency based medical curriculum as recommended by the medical council of India."
• "Small group sessions ensured active learning and good interaction among participants."
About the active-learning tools
• "FCR seems to be easily implementable in Indian colleges as it can be independently incorporated in the course curriculum."
• "CBL session was in line with the new Medical Council of India curriculum, and participants were able to identify what will be required of them in the new curriculum."
Recommendations
• "Conduct periodic annual workshops to modify the teaching learning techniques at par with the changing curricular requirements."
• "A follow-up review of adaptation of any of these tools/methods by the participants in their parent institute can be a broad measure of effectiveness of such workshops."
• "A real-life teaching learning experience can be demonstrated by involving a small group of UG students."

CBL, case-based learning; FCR, flipped classroom; UG, undergraduate.

conclusion can be drawn from the small sample size in the present study, the observed trend suggests that further studies are necessary to address this issue in the future.

Building up of national networks and multiplier effect. One major aim of the workshop series was to create a national network of physiology teachers as future mentors of active learning in India. We anticipated this would yield a "multiplier effect" to expand the network of trained faculty and the development and dissemination of techniques of learner-centric active education in physiological sciences. Table 6 provides a summary of the initiatives that were undertaken in this direction by participants from each workshop. At the brainstorming meeting in AIIMS Delhi in January 2019, a participant of *workshop 2* took on the task of organizing with support of the COC the "Hands-on Medical Teaching Methodologies" workshop in 2019 (*workshop 4*). This workshop drew upon the strengths and limitations of the previous tri-series workshop and extended the scope of the active-learning program, not only to physiology, but also to other medical and paramedical disciplines. Such post-workshop activities by the participants at their local levels lend support to fructify the aim of the IUPS workshop series to create and expand the networks among teachers, resulting in a multiplier effect in appreciation and dissemination of active-learning tools for physiology education in India. It is to be appreciated that quality education with an inbuilt multiplier system is a way to achieve long-term sustainable developmental goals that tap on managerial insights in medical education (4a, 47).

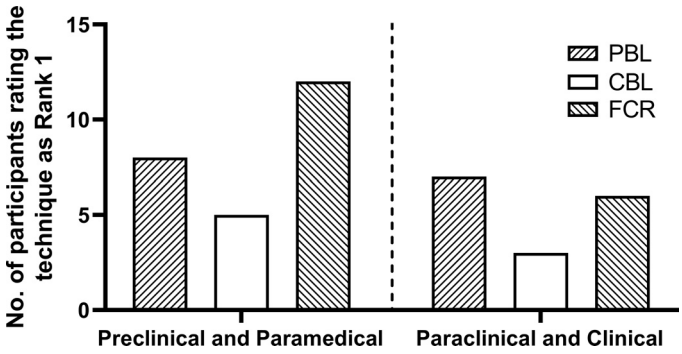


Fig. 3. Participants' response to a question (*question 12*: "Rank the techniques presented in this workshop based on their feasibility in your institute") in the Workshop's General Feedback survey held at Sikkim Manipal Institute of Medical Sciences, Sikkim Manipal University, Gangtok in November 2019. Bars represent the no. of participants who ranked each technique as *rank 1*. The bars are clustered for responses obtained from participants belonging to the following disciplines: Preclinical (Anatomy, Biochemistry, Biotechnology, and Physiology) and Paramedical (Nursing and Physiotherapy) (data were combined for both of the categories); and Paraclinical (Forensic Medicine, Microbiology, Pathology, and Pharmacology) and Clinical (Anesthesia, Community Medicine, Dental Surgery, Dermatology, General Surgery, Hospital Administration, Internal Medicine, Obstetrics and Gynecology, Ophthalmology, Otorhinolaryngology, Pediatrics, Psychiatry, Radiology, and Respiratory Medicine) (data were combined for both of the categories). Note that 41 out of 54 participants responded to *question 12*. CBL, case-based learning; FCR, flipped classroom; PBL, problem-based learning.

Useful Lessons from the Workshop Series

The following section summarizes the major observations made at different stages of the implementation of the series of workshops, which bear some instructive values for future efforts in this line.

Demographic issues. Table 7 summarizes the centerwise distribution and demographic characteristics of participants. Of the 72 participants in *workshops 1–3*, the majority were early career faculty members affiliated with medical schools (59 out of 72). The representation from life sciences and veterinary sciences was modest (4 and 9 participants, respectively). The 54 participants of *workshop 4* belonged to preclinical (20 participants), paraclinical (11 participants), clinical (18 participants), and paramedical departments (5 participants), with most participants being from early or midcareer level (see Table 7 for details).

Additionally, it was noted that workshop *series 1–3*, unlike *workshop 4*, had participant faculty members of physiology from government (47 out of 72 participants) as well as private (25) institutions. For each center, it was apparent that the nonequitable distribution of resources across states, between the rural-urban zones and the public-private sectors (13), would prove to be yet another challenge. Workshop participants joining from either government or private institutions had different exposures to the best practices of physiology education based on the resources and the infrastructure available in their parent institutions.

In cognizance of the above-mentioned issues, the workshop resource faculty team had planned to focus actively on capacity building by mentoring participants with practical insights on "how" to implement the active-learning tools in their own

Table 6. *Role of workshop participants in capacity building for physiology education in India*

Discussant (Workshop Participated)	Institution (Year of Establishment)	Details of Workshop Conducted
S. Srivastava (*workshop 1*)	Department of Physiology, AIIMS-Jodhpur Rajasthan (2012)	CBL on myocardial infarction conducted in December 2018 for 100 first-year MBBS students. Language barrier found to be a major hindrance, since a large population of students faced difficulty in following English. This was overcome by speaking in both English and Hindi (the Indian, vernacular language) to avoid the language barrier of this subgroup of Hindi speaking students.
J. Deka (*workshop 2*)	Department of Physiology, Silchar Medical College, Silchar, Assam (1968)	PBL on myasthenia gravis conducted for 90 first-year MBBS students in January 2019. Students were divided into five groups, with each having a respective team leader. Case scenario on the topic presented was followed by brainstorming session on the given scenario on the basis of prior knowledge. Students showed significantly more interest in the didactic lecture on neuromuscular junction that followed the PBL. 80% of students gave positive feedback, whereas 20% remained inactive.
C. Bodhe (*workshop 3*)	Department of Physiology, Government Medical College, Miraj, Maharashtra (1962)	FCR held at the Krishna Institute of Medical Sciences (KIMS) in Karad, Maharashtra in December 2018 on neuromuscular junction to familiarize and sensitize 27 KIMS faculty members from preclinical and clinical disciplines. The FCR session showed an overall learning gain of 57% based on structured questionnaires.
C. Suryavanshi (*workshop 3*)*	Department of Physiology, Kasturba Medical College, Manipal, Karnataka (1953)	FCR conducted for 125 medical students on muscle tone-central nervous system in December 2018 and on temperature regulation in March 2019. The FCR sessions registered an initial challenge by students for coming to class with prior preparation, but ~60% came prepared for the first FCR class.

Workshop 4 in Sikkim Manipal Institute of Medical Sciences (SMIMS), Sikkim Manipal University (SMU), Gangtok, Sikkim, was proposed and coordinated by a participant (R. Dey) of *workshop 2*. For details, see *Brainstorming and workshop 4* under *Organizational Mechanics*. AIIMS, All India Institute of Medical Sciences; CBL, case-based learning; FCR, flipped classroom; MBBS, Bachelor of Medicine and Bachelor of Surgery; PBL, problem-based learning. *Additional note during the proofreading: Two of the participants (KRN and CS) of *workshop 3* further conducted research on **Teaching Innovations** using team-based learning (TBL) methodology on 250 students. Vide: **Nayak KR, Punja D, Suryavanshi C.** Impact of readiness assurance process and faculty feedback on individual application exercises: a model for continuous assessment in physiology. *Adv Physiol Educ* 44: 509–515, 2020. doi:10.1152/advan.00065.2020.

academic settings aside from sharing the knowledge and skill sets required to conduct each technique with the expected level of competence. To fulfill this additional goal, the resource team adopted two approaches at the end of each session:

1) Encourage sufficiently interactive freewheeling discussions by participants with the resource team to share their unique challenges and to identify solutions specific to their academic settings.

2) Identify the educational tools that participants considered to be implementable with immediate plans to initiate and operationalize in their own institution and why.

This "learned effect" among the resource faculty from *workshops 1–3* showed its benefit in *workshop 4*. This is evident from the comparison of participants' responses to the General Feedback survey between the tri-series workshop and *workshop 4*, showing an improvement (Mann–Whitney U score = 901; P = 0.002) in *workshop 4* participants' responses on the related question (see Table 2, *question 6*: adequate time required for critical and interactive learning was provided in the workshop). Responses for the remaining questions in the General Feedback Questionnaire did not differ statistically in responses received from *workshops 1–3* and *workshop 4*.

Two interesting points of potential importance emerged from the demographic analysis. First, an understanding of the challenge of primarily English-based communication and instruction in health science institutions in India needs to be addressed while practicing a learner-centric interactive format. In several of the resource-poor districts and towns across the north and eastern regions of India, vernacular is used as the primary medium of instruction in most schools. As a result, when students from such schools enroll in college and professional institutions immediately after their higher secondary school education, they

Table 7. *Demographic data of workshop participants at physiology education workshops held in India in 2018 and 2019*

	Workshop and Center with Location			
	Physiology Tri-Series Workshop			Medical Teaching Methodologies
Demographic Characteristics	AIIMS Jodhpur (*workshop 1*)	NEIGRIHMS Shillong (*workshop 2*)	GMC Kozhikode (*workshop 3*)	SMIMS Gangtok (*workshop 4*)
Age, yr	40 ± 8	42 ± 6	40 ± 7	40 ± 7
Delegates, *n*	22	18	32	54
Gender (men/women)	16:6	7:11	10:22	19:35
Stage of career (early/mid/late)	15:3:4	9:8:1	22:5:5	26:19:9

Early career denotes academic affiliations as lecturer, senior demonstrator, or assistant professor; mid-career as associate professor; and late career as additional professor or professor. AIIMS, All India Institute of Medical Sciences; GMC, Government Medical College; NEIGRIHMS, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences; SMIMS, Sikkim Manipal Institute of Medical Sciences.

face a serious language barrier, hindering their participation in both conventional and learner-centric academic sessions. Physiology either in the basic sciences program or in medicine, veterinary, nursing, and paramedical courses is considered as a relatively difficult, concept-driven subject. It becomes even more challenging for those students for whom language is yet another barrier to overcome. The use of a bilingual approach using both English and vernacular languages as the medium of instruction could be one practical approach, as highlighted by a participant of *workshop 1* at the brainstorming session (Table 6). Besides better understanding of the subject, this approach has the possibility of promoting increased communication skills among healthcare providers and end-users (1, 4, 12).

Second, there was a consistently higher (74 out of total 126 participants) representation of women versus men as participants at all workshops, except in *workshop 1* (see Table 7 for details). Interestingly, there was also a higher representation of women (7 out of total 10 members) in the resource faculty team. Although we are not able to carry home any leads based on the data available, this issue may be systematically examined in view of associated sociobiological biases, if any (7, 15, 48).

Core organizational issues. Narrative feedback responses, discussions, and inputs from participants, observers, and support groups during the workshops and those presented in discussions after the workshops identified important core organizational themes.

- Motivation: The idea of holding a series of workshops on education tools across the length and breadth of the country is not only a funding-intensive and resource-intensive venture, it requires a group of highly motivated members and open, dynamic, and committed faculty organizers at the organizational core. The workshop series reported in the present paper was successful because the organizers could identify a group of dedicated members at the center of the organization and cooperative local committees. Additionally, the organizers could build connections with an international organization like IUPS and a central funding agency like ICMR and couple those agencies to be on the same page. The IUPS connection provided immense support at the academic resource levels as international experts of the IUPS became engaged in discussions with national resource faculty for the creation of resource materials and a feasible workshop planning. Gaining confidence from a central agency like ICMR for funding support by the COC ensured the availability of resources for each LOC to facilitate their motivation to undertake the operation.
- Constant dialogue: The activities like site visits, formation of LOCs through extensive discussions, constant dialogue among LOCs and COC, inducting LOC members of one center to the workshop of the other centers, and budgetary assurance to LOCs paved the way to necessary activism.
- Commitment: The organization of a series of workshops in sequence with an international resource faculty team demanded sufficient managerial efficiency in planning and time management. The commitment levels and organizational efficiencies of LOCs were critical factors in this regard. Indeed, the gateway of final deliverables to the successful execution of plans depends on the LOC's proficiency and wholeheartedness.
- Sufficient time frame: The process of holding such an ambitious venture is dependent on the critical factor of optimal preparation time so that the process did not suffer from either time constraint or slackness. In our experience, we had a little more than 1 yr between the time of raising the ideas to the completion of the first series of workshops (*workshops 1–3*). We sensed that it was adequate, but an additional 2–3 mo would have been more effective.
- Student engagement: We noted a few deficiencies in the organizational process during *workshops 1–3*. An important activity that was consistently missing was the involvement of students in the workshop activities. With an appreciation of the long-term benefit that such activity might yield, a well-designed student activity was made an integral part of *workshop 4*. Specifically, 25 undergraduate students of the SMIMS-SMU eloquently discussed five diverse topics related to medical education and physiology teaching, the details of which are in the meeting report (14).

Collectively, the planning and arrangement for logistics of *workshops 1–4* and the idea of a structured brainstorming were indeed unique and served useful purposes toward addressing specific organizational challenges in India, as outlined in Table 1.

Active-learning approaches suit to support competency-based curricula. In September 2018, the MCI announced that the Undergraduate Medical Education curricula would adopt a competency-based framework and projected a tactical approach to establish the uniform standards of medical education (34). The shift to a competency-based framework required schools to implement teaching methods that support student-centered educational approaches and promote self-directed learning (8). The three teaching approaches selected for the workshop series align well with a competency-based curriculum. PBL and CBL develop the skill of self-directed learning, as group members learn how to identify and remedy any learning gaps in clinical context (8). CBL provides more structure than PBL and extends the large-group session into diagnosis and patient management (21). FCR supports the learners' ownership of the learning environment with multiple forms of assessment and mentoring that allow learners to gauge their progress (27). Each of the approaches selected for the workshops reinforced the key aspects of competency-based learning.

Finally, the participants provided several interesting suggestions for related activities in future workshops, a few of which appeared to be non-canonical and noteworthy. Participants who hailed from a life sciences background suggested the use of non-medical problems in CBL and PBL to allow for better concentration and focus on the technique per se rather than the subject content. Furthermore, it was suggested that future workshops be planned to introduce sessions on how to design cases, concept maps, and problems covering core physiology topics that require integrated understanding of anatomical, biochemical, humoral, genomic, and proteomic interactions in health rather than in disease states. One participant's feedback hinted upon the need for future workshops to promote how to design a curriculum to cater to courses in physiology and creation of assessment tools.

Conclusion

Organizing a series of Physiology Education workshops in India as an IUPS initiative posed unprecedented challenges due

to factors innate to the Indian context, ranging from diversities in geo-linguistic-ethnic background and educational practices to nonequitable distribution of resources across the country. These organizational challenges were addressed through tailor-made approaches carved out of the deliberations and brainstorming conducted at the levels of COC, resource faculty team, and LOC as they worked in unison to implement the conceived plan systematically. Specific emphasis was laid during the workshop series to facilitate capacity building and creation of a national network of physiology instructors interested in promoting active-learning techniques that was subsequently followed up with a brainstorming meeting to assess the progress towards fulfillment of these goals. Interestingly, the workshops coincided with the launch of a competency-based curriculum by MCI, which greatly added to the relevance of the IUPS workshop series. We conclude that the initiatives of the tri-series Physiology Education workshop in 2018 and the Medical Teaching Methodologies workshop in 2019 were successful in the promotion of active-learning tools in India and provided leads for similar activities in India and beyond.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

J.S., J.C., D.G., S.M.B., L.M.P., S.G., R.S., M.B., and R.G.C. conceived and designed research; D.S.C., D.G., S.M., S.M.B., S.G., R.S., M.B. and B.B. performed experiments; D.S.C., D.G. and S.M. analyzed data; D.S.C., J.S., D.G., and R.G.C. interpreted results of experiments; D.S.C. and D.G. prepared figures; D.S.C., J.S., D.G., S.M.B., L.M.P., and R.G.C. drafted manuscript; D.S.C., J.S., J.C., D.G., S.M., S.M.B., L.M.P., S.G., R.S., M.B., and R.G.C. edited and revised manuscript; D.S.C., J.S., J.C., D.G., S.M., S.M.B., L.M.P., S.G., R.S., M.B., B.B., and R.G.C. approved final version of manuscript.

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